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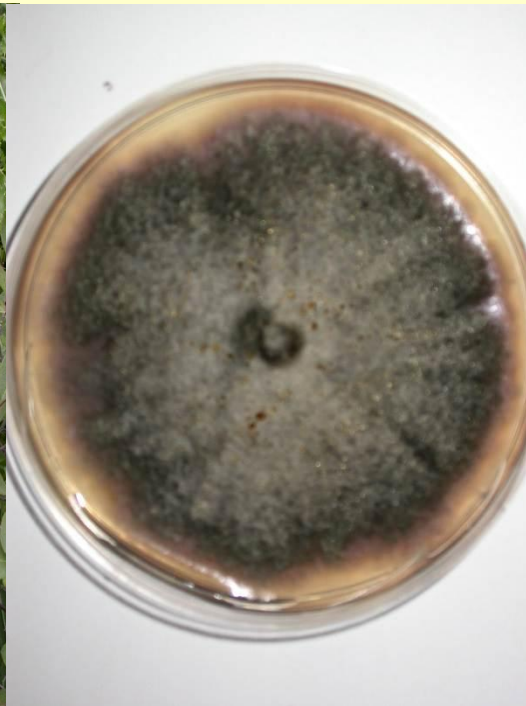
***Phoma macrostoma:* the science of a bioherbicide to control broadleaved weeds**

Saskatoon Research Centre
Karen Bailey

Canada 

A Fungus for Broadleaved Weed Control

- *Phoma macrostoma* discovered on Canada thistle
- Naturally-occurring from Alberta to Nova Scotia, UK
- Symptoms: photobleaching & root growth inhibition
- White tip disease of CT Evans et al. 2013. Tracing the origins of white tip disease of *Cirsium arvense* and its causal agent, *Phoma macrostoma*. Weed Research 53: 42-52.



Phoma is broad spectrum

Dicots are susceptible

- Aster family
- Legume
- Brassica



Monocots are tolerant

- Grasses
- Cereals

Exceptions occur based on host susceptibility, plant age, amount applied, and number of applications

- Trees
- Ornamentals
- Herbs
- Cucurbits, Tomato, Bell Pepper

Bailey et al. 2011. The effects of *Phoma macrostoma* on nontarget plant and target weeds species. *Biological Control* 58 (3): 379-386.

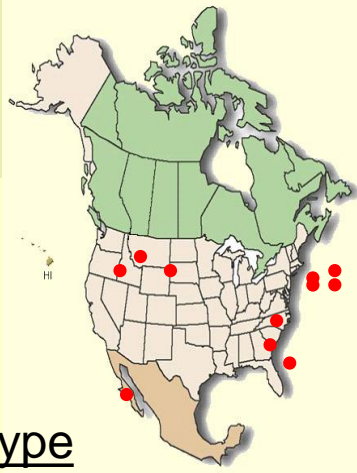
Solid State Fermentation - Granular Formulation



Turf Broadleaf Weed Spectrum and Turf Safety

PMRA and California Registration

- 7 years of research
- 129 Efficacy
- 69 Phytotoxicity



Weeds

Dandelion

Clover

Plantain

Chickweed

Canada Thistle

Black Medic

Buckhorn

Spotted Spurge

CA Bur clover

Cudweed

Ragweed

Chamomile

Wild Mustard

English Daisy

Turf type

Kentucky bluegrass

Perennial ryegrass

Annual ryegrass

Red fescue

Tall fescue

Bent grass

Smooth brome grass

Meadow brome grass

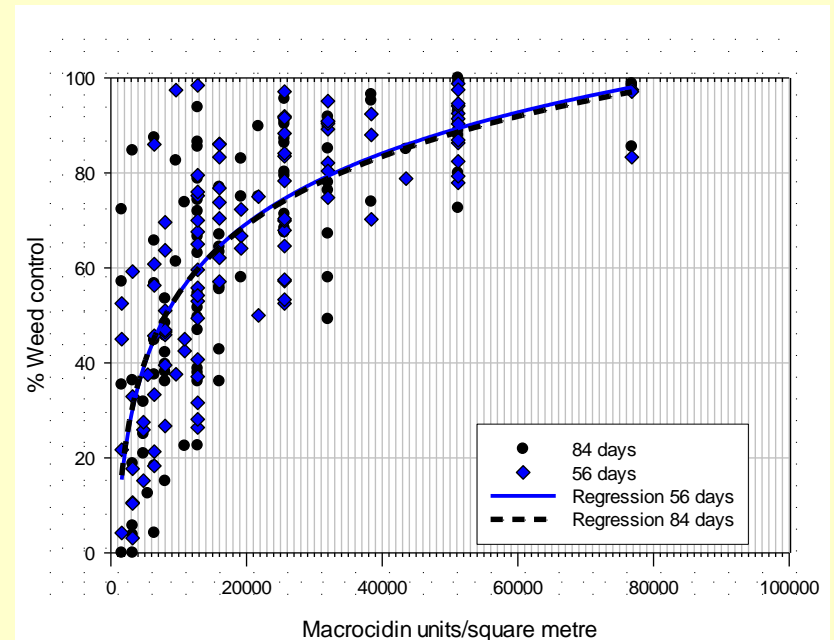
Timothy grass

Turfgrass mixtures

Bermuda grass

Spot treatment	Pre-emergent	Post-emergent
2-3X /season	1X / season	2-3X /season
2g per 20 cm diam	16 g per sq m	32 g per sq m
10^3 cfu/g with 400 MU/g		

Dandelion control



Efficacy: Pre-emergent dandelion



Photos from Scotts Miracle-Gro

Efficacy: Post-emergent dandelion

Two applications
June/July

Photos from Scotts Miracle-Gro



How Phoma works

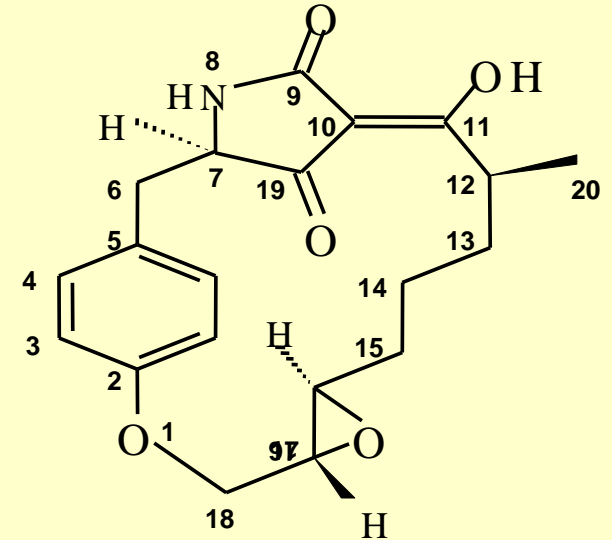
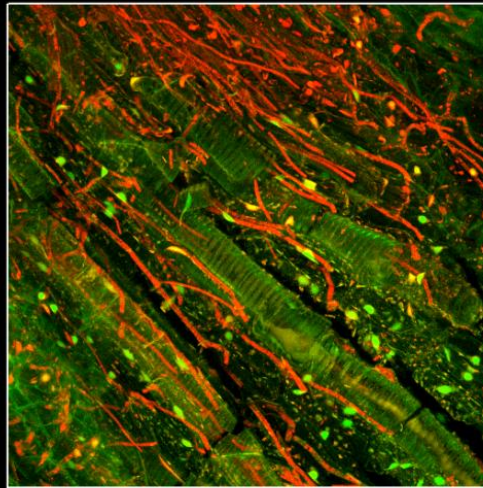
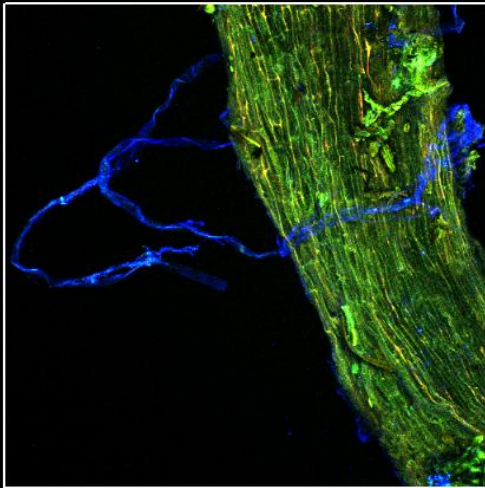
Biologically

Susceptible: growth to vascular system delivering macrocidins

Resistant: restricted to outer root cells

Chemically

Macrocidins phytotoxins produced by Phoma causing photobleaching & root inhibition in some plants



Bailey et al 2011. Determining the infection process of *Phoma macrostoma* that leads to bioherbicidal activity on broadleaved weeds. *Biological Control* 59: 268-276.

Graupner 2003. Macrocidins: Novel cyclic tetramic acids with herbicidal activity. *J. Natural Products* 66:1558-1561.

Environmental Limitations

It does not matter whether it is a biological or a chemical, all pest control products have some environmental limitations.

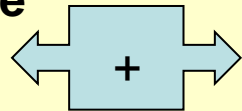
Phoma weed control depends on the age/size of weed and having actively growing weeds.

Actively growing weeds depend upon having the optimal temperature, moisture, and fertility regime.

Key criteria

Temperature

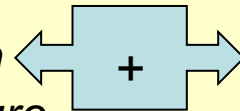
Air, Soil



Moisture

Precipitation, Irrigation

Residual soil moisture



Weed age

Young, small

Older, large

Other factors

Fertility

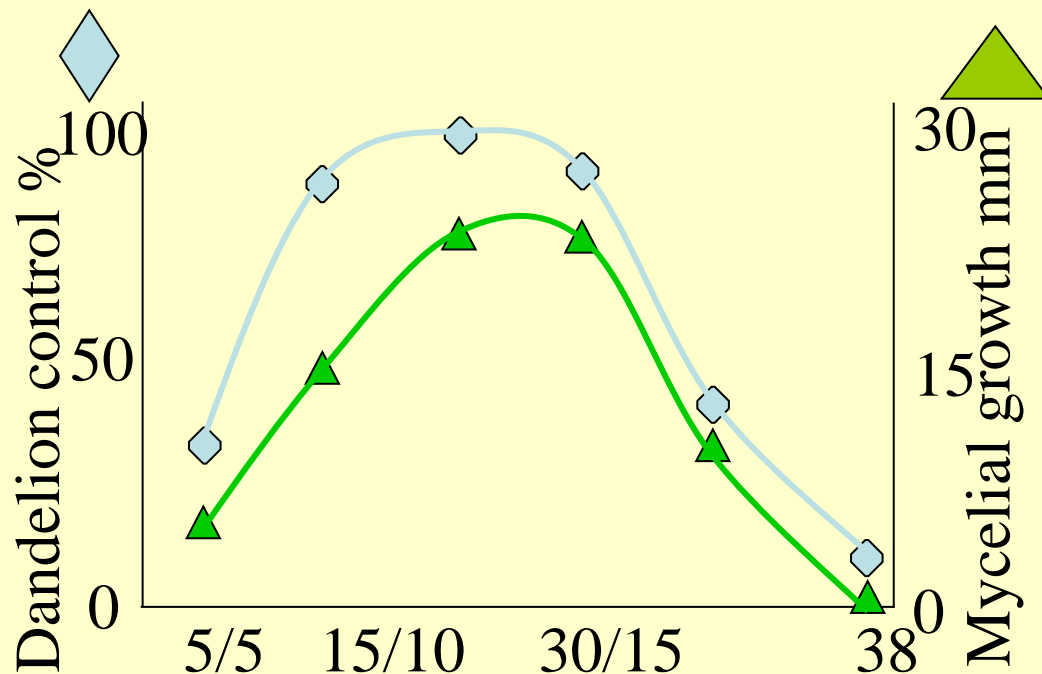
None vs Commercial fertilizers

Soil Type

Sand, Loam, Clay

Environmental Limitations

Weed control
Optima 15–30°C
Extremes 10–30°C



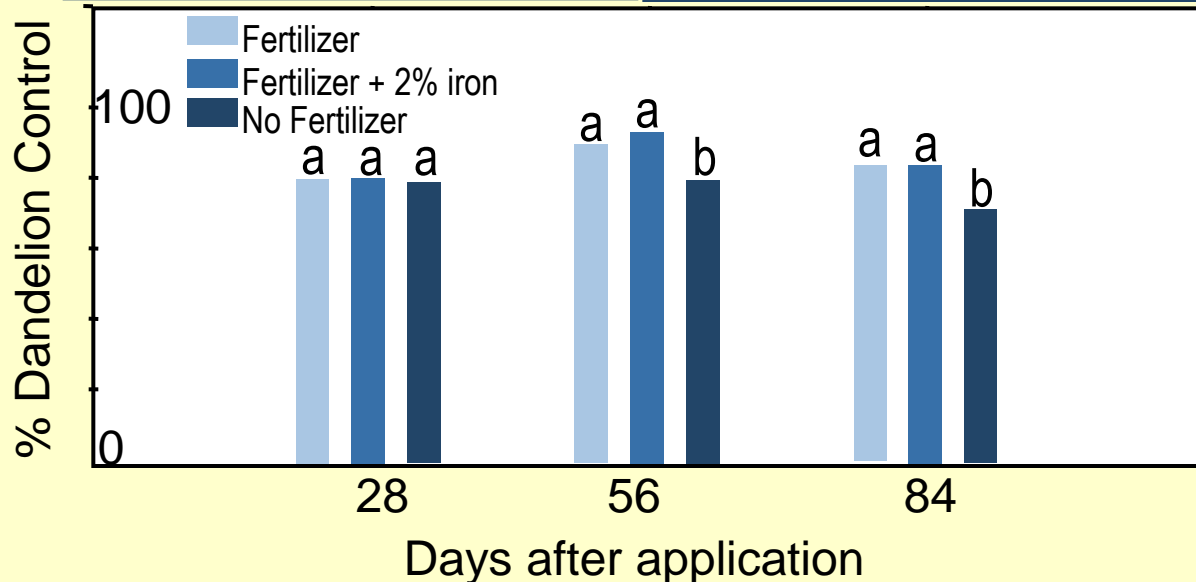
- Does not need to be watered-in
- Light precipitation or irrigation before or after application is not harmful
- Too much water can reduce efficacy (75mm -125mm at one time or close sequentially)
- Efficacy best in clay, loam, then sand

Phoma plus Scotts Turf Builder with 2% Iron: 14 days (L) and at 86 days (R) after application

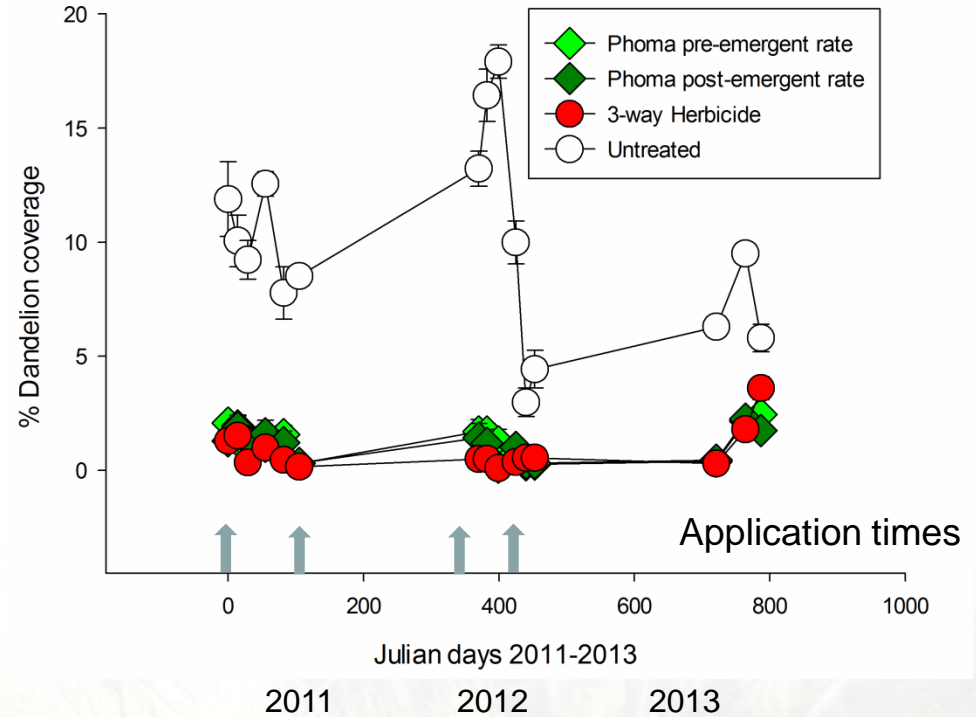
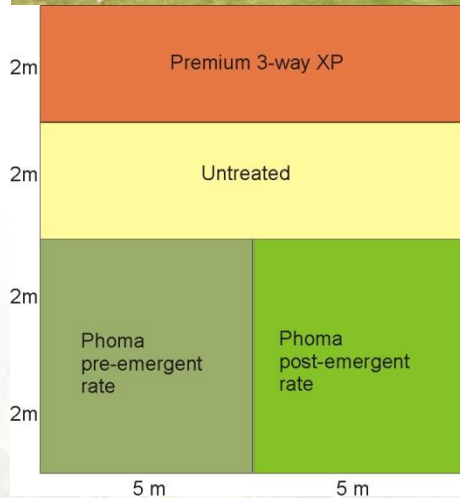


Dandelion control with Phoma was 80-100% at three sites (Guelph, Saskatoon, Marysville).

Commercial fertilizers increased efficacy by 10-15% over the no fertilizer treatment at two sites (Saskatoon, Marysville)



New Research: Multi-year Use of Phoma 2011-2013



Spring and fall applications using pre- & post-emergent rates

Applied in 2011 & 2012 and then no application in 2013

Phoma = 3-way herbicide on dandelion

Small weed increases in year when Phoma and 3-way herbicide not used

New Research: Using Phoma-treated grass as garden mulch



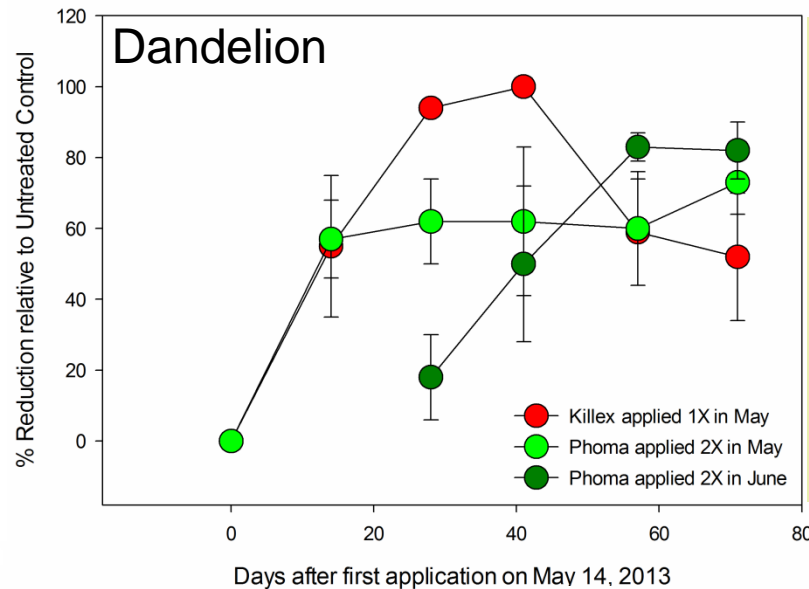
No mulch

Mulched

Phoma –treated grass clipping applied to emerging sunflower (highly susceptible).

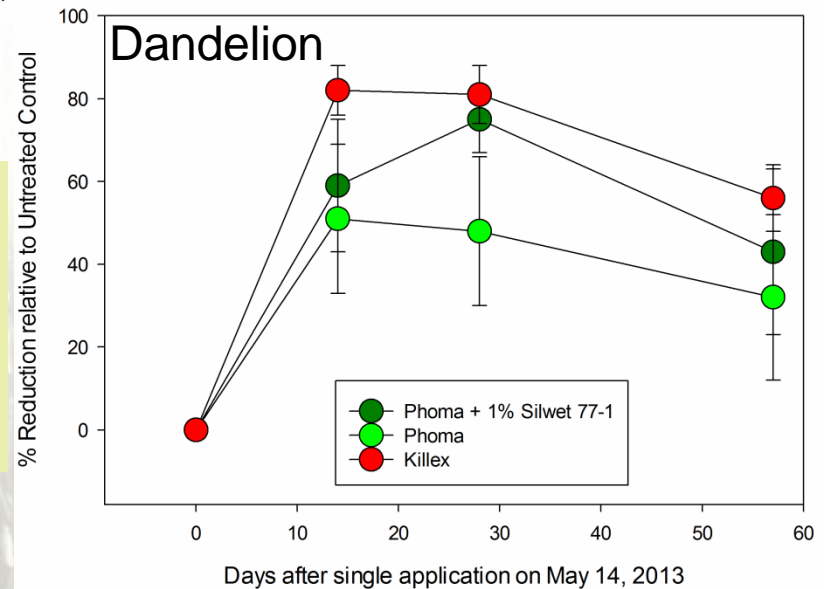
No signs of Phoma infection on sunflower.

New Research: Foliar Spray Application



Application Dates

- 2 weeks apart
- May 14, 28
dry, cool
- June 11, 24
moist, warm



Future Work

Spray-dried, wettable powder containing *Phoma* for dandelion

Adjuvant Test

- Silwet 77-1
- Single application
- a.i. equivalence to granules $\leq 32 \text{ g/m}^2$

Status of the *Phoma* bioherbicide

- Phoma technology is owned by AAFC
- It is licensed to The Scotts Company
- Scotts received conditional approval for use on turfgrass by PMRA in 2011 & EPA in 2012
- Approved for application of a granular formulation
 - **Spot RTU (2-3X per season)**
 - **Pre-emergent broadcast application**
 - (1X per season)
 - **Post-emergent broadcast application**
 - (2-3X per season)
 - **Domestic and Commercial label**



In Pilot Scale moving to Commercial reactor

Phoma is under scale up development
Not yet ready for commercial launch.



Phoma Turf Tips

- Phoma formulated as broadcast granule
- Apply to established or newly seeded turf any time from spring through fall as spot treatment, pre-emergent or post-emergent broadcast
- It has broad spectrum activity on several weed species; safe to most grasses, trees, and some ornamentals
- The level of control achieved depends on the weed type, weed age, amount applied, number of applications, and environment.
- The environmental conditions that support active weed growth also support Phoma weed control



Phoma Turf Tips

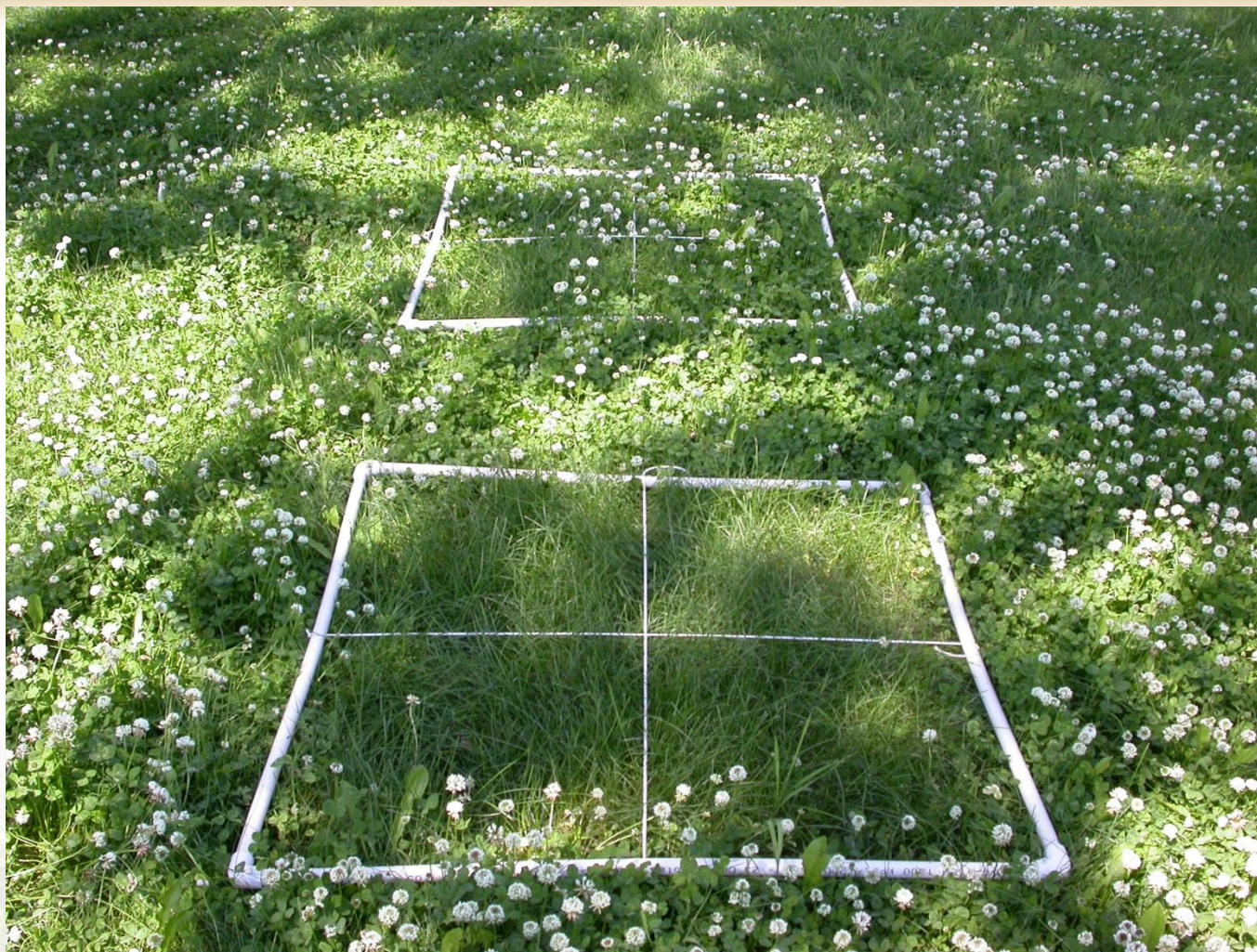
- Emerging and young weeds most susceptible; well-established weeds need repeat applications or higher rates
- Mean air temperature about 20 C (± 5 C) and good soil moisture are crucial
- Approx. 25 mm of water within 24-72hr of application helps; but too much water at one time reduces efficacy; weekly irrigation (25-30 mm) is helpful
- Fertilizers may improve Phoma efficacy
- Soil type influences level of control (less control in sandy soils)
- Repeated pre-emergent use over multiple years prevents new weeds from establishing



After Phoma (above);
Before Phoma (below)



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Contact information:
Agriculture & Agri-Food Canada
Karen.Bailey@agr.gc.ca